

CSE 259 - Logic in Computer Science

Fall 2024

Recitation-2

Waqar Hassan Khan



Recursion - Definition

Definition: Recursion is a technique in which one predicate uses itself to find the truth value.

Example:

```
predecessor(X, Z) :- parent(X, Z).
```

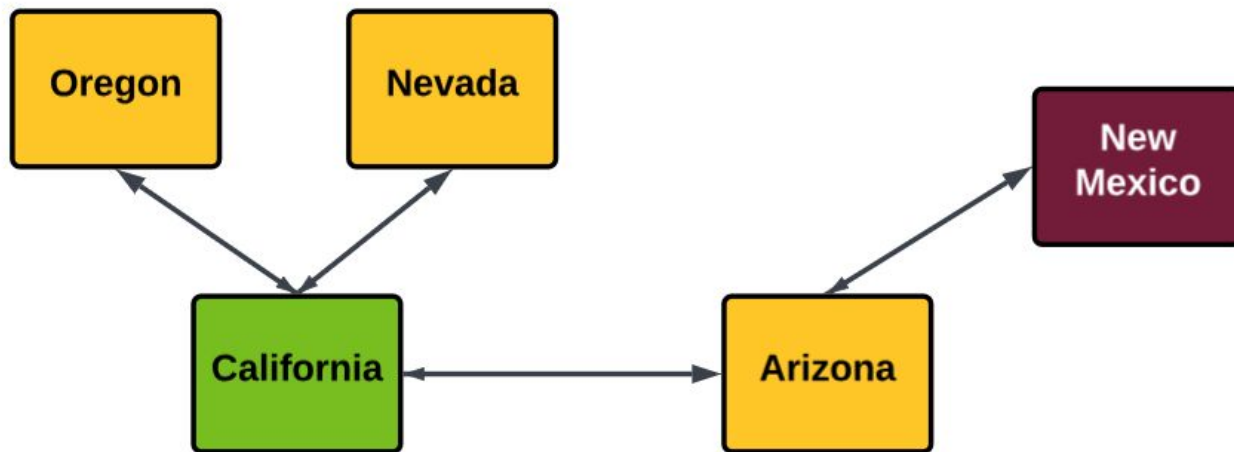
Base case

```
predecessor(X, Z) :- parent(X, Y),predecessor(Y, Z).
```

Recursion - Applying recursion

Last time we solved this problem had a **limitation**: Travelling from Oregon to New Mexico was not possible :(

Solution: Using recursion



Recursion - Applying recursion

```
1  % facts
2  next_to(california, arizona).
3  next_to(california, oregon).
4  next_to(california, nevada).
5  next_to(arizona, new_mexico).
6
7  % a rule where we write the logic of when two states are connected
8  connected(A, B) :- next_to(A, B) ; next_to(B, A).
9
10 /*
11  | * recursive rule
12  | */
13 path(A, B) :- connected(A, B).
14 path(A, B) :- connected(A, C), C \== B, path(C, B).
15
16 travel(A, B) :- path(A, B).
```

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).

path(A, B) :- connected(A, C), C \== B, path(C, B).

A **B** **A** **B** **B**
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico)

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).

path(A, B) :- connected(A, C), C \== B, path(C, B).

A **B** **A** **B** **B**
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico)

A **B** **A** **C** **C** **B** **C** **B**
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico)

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).

path(A, B) :- connected(A, C), C \== B, path(C, B).

A **B** **A** **B** **B**
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico).

A **B** **A** **C** **C** **B** **C** **B**
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico).

A **B** **A** **B** **B**
path(california, new_mexico) :- connected(california, C), C \== new_mexico, path(C, new_mexico).

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).

path(A, B) :- connected(A, C), C \== B, path(C, B).

A **B** **A** **B** **B**
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico).

A **B** **A** **C** **C** **B** **C** **B**
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico).

A **B** **A** **B** **B**
path(california, new_mexico) :- connected(california, C), C \== new_mexico, path(C, new_mexico).

A **B** **A** **C** **C** **B** **A** **B**
path(california, new_mexico) :- connected(california, arizona), arizona \== new_mexico, path(arizona, new_mexico).
path(california, new_mexico) :- connected(california, oregon), oregon \== new_mexico, path(oregon, new_mexico).
path(california, new_mexico) :- connected(california, nevada), nevada \== new_mexico, path(nevada, new_mexico).

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).

path(A, B) :- connected(A, C), C \== B, path(C, B).

A **B** **A** **B** **B**
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico).

A **B** **A** **C** **C** **B** **C** **B**
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico).

A **B** **A** **B** **B**
path(california, new_mexico) :- connected(california, C), C \== new_mexico, path(C, new_mexico).

A **B** **A** **C** **C** **B** **A** **B**
path(california, new_mexico) :- connected(california, arizona), arizona \== new_mexico, path(arizona, new_mexico).
path(california, new_mexico) :- connected(california, oregon), oregon \== new_mexico, path(oregon, new_mexico).
path(california, new_mexico) :- connected(california, nevada), nevada \== new_mexico, path(nevada, new_mexico).

A **B** **A** **B**
path(arizona, new_mexico) :- connected(arizona, new_mexico).

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).



GNU Prolog console

File Edit Terminal Prolog Help

GNU Prolog 1.5.0 (64 bits)

Compiled Jul 8 2021, 12:22:53 with gcc

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```
| ?- consult('E:/Programming/TA/ASU-CSE-259-Prolog/Rec
compiling E:/Programming/TA/ASU-CSE-259-Prolog/Recitat
E:/Programming/TA/ASU-CSE-259-Prolog/Recitation-3/trav
```

yes

```
| ?- travel(oregon, new_mexico).
```

true ?

yes

```
| ?-
```

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).



GNU Prolog console

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```
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compiling E:/Programming/TA/ASU-CSE-259-Prolog/Recitat
E:/Programming/TA/ASU-CSE-259-Prolog/Recitation-3/trav
```

yes

```
| ?- travel(oregon, new_mexico).
```

true ?

yes

```
| ?-
```

Cut

- Represented by !
- Always succeeds - in the rules it is considered as true
- Prevents Backtracking

Cut - example

```
1  % facts
2  red(apple).
3  red(lexus).
4  red(honda).
5  blue(monkey).
6
7  car(honda).
8  car(lexus).
9  bike(monkey).
10
11 fun(X) :- red(X), car(X).
12 fun(X) :- blue(X), bike(X).
13
```

```
yes
| ?- fun(X).
```

```
X = lexis ?
```

```
yes
| ?- fun(X).
```

```
X = lexis ? ;
```

```
X = honda ? ;
```

```
X = monkey
```

```
yes
| ?-
```

Cut - example

```
1  % facts
2  red(apple).
3  red(lexus).
4  red(honda).
5  blue(monkey).
6
7  car(honda).
8  car(lexus).
9  bike(monkey).
10
11 fun(X) :- red(X), car(X), !.
12 fun(X) :- blue(X), bike(X).
13
```

- First, X is bound to apple. apple is red, so red(X) is true. Then car(X) is checked and it is false. So, we get back to red(X).
- Now X is bound to lexus. lexus is red and a car. So we reach the cut operator. And then stop backtracking

```
?- fun(X).
X = lexus
yes
```

Cut - example - order matters!

```
1 % facts
2 red(apple).
3 red(honda).
4 red(lexus).
5 blue(monkey).
6
7 car(honda).
8 car(lexus).
9 bike(monkey).
10
11 fun(X) :- red(X), car(X), !.
12 fun(X) :- blue(X), bike(X).
13
```

```
yes
| ?- fun(X).
X = honda
yes
| ?-
```

Cut - example - order matters!

```
1  % facts
2  red(apple).
3  red(honda).
4  red(lexus).
5  blue(monkey).
6
7  car(honda).
8  car(lexus).
9  bike(monkey).
10
11 fun(X) :- red(X), !, car(X).
12 fun(X) :- blue(X), bike(X).
13
```

- X is bound to apple: apple is red. Then ! is true. The apple is not a car. Now, we need to get back to red(X) for more solution. But we can't get past the ! operator. So, not backtracking for more solution

```
| ?- fun(X).
no
| ?-
```


Cut - example - order matters!

```
1  % facts
2  red(apple).
3  red(honda).
4  red(lexus).
5  blue(monkey).
6
7  car(honda).
8  car(lexus).
9  bike(monkey).
10
11 fun(X) :- !, red(X), car(X).
12 fun(X) :- blue(X), bike(X).
13
```

- ! is true
- X is bound to apple, X is red, X is not a car. So, we get back to red(X). The cut was before red(X) so no problem getting back.
- honda and lexus is found.
- Finally we get back to the cut. We stop backtracking which is why fun(X) :- blue(X), bike(X) is not checked.

```
yes
|  ?- fun(X).
X = honda ? ;
X = lexus
yes
```